

Quantum Physics and the Identity of Indiscernibles

There has been much discussion in the literature ([1], [2], [3], [4], [5], [6]) as to whether atomic particles of the same species \mathcal{P} , which share the same intrinsic state-independent properties of mass, spin, electric charge etc. violate the Leibnizian Principle of the Identity of Indiscernibles (PII). It seems that, while there is now that one of these, their state-dependent properties may also all be the same. The answer depends on what exactly the state-dependent properties are taken to be. Other authors have concentrated on the question of whether the state-dependent properties can be identified with the eigenvalues of the quantum-mechanical state. This runs into the difficulty that in general indistinguishable particles, treated in first quantization or in entangled states that do not permit ascribing maximally specific pure states to each particle. The fact that can be done to describe the individual particles by superposition mixtures.

new para.

[The present work follows a different line of attack. The state-dependent properties are plausibly identified with all the monadic and relational properties that can be ascribed in terms of physical magnitudes expressed with self-adjoint operators that can be defined for the individual particles.

IP says that permitted observables must satisfy $\langle \phi | Q | \phi \rangle = \langle \phi | P^{-1} Q P | \phi \rangle$ for all states $|\phi\rangle$ and all particle permutations P

Now for a two-particle system, defining $Q_1 = Q \otimes I$ and $Q_2 = I \otimes Q$, where Q is a one-particle observable, and are concerned with marginal probabilities of the form $\text{Prob}^{|\Psi\rangle}(Q_1 = q^1)$ and $\text{Prob}^{|\Psi\rangle}(Q_2 = q^2)$ where $|\Psi\rangle$ is the quantum-mechanical state of the joint system and q^i is some eigenvalue of the self-adjoint operator Q_i and also with relational properties expressed by conditional probabilities of the form $\text{Prob}^{|\Psi\rangle}(Q_1 = q^1 | Q_2 = q^2)$ and $\text{Prob}^{|\Psi\rangle}(Q_2 = q^2 | Q_1 = q^1)$.

new para [It must be recognized that Q_1 and Q_2 are not themselves observables on the two-particle system, where limitations on possible 'observables' due to the Indistinguishability Postulate (IP) introduced in [7] are taken into account. ** Extension* Nevertheless it is argued that from an ontological point of view there are the appropriate quantities to investigate in discussion of PTI.

new para [The analysis is extended to three-particle situations in order to ~~show~~ ^{present} examples of the case of particles whose states support hyper-~~order~~ ^{irreducible} representations of the Symmetric Group.

new para [It is concluded that the weakest form of PTI involving all relevant modes

ord relativ properties is violated
for boson, fermion and hyper-order
particles, tested in first generations.

[1] Barnette Cortes, A.

[2] Barnette, R. L.

[3] Ginzberg, A.

[4] Teller, P.

[5] Shodmi, Y.

[6] Van Freeman, B.

[7] Greenberg o. c. and ^{MESSIAH} Pomak, A. M. L.